SECOND PRIZE 95 REVOLUTION IN MILITARY AFFAIRS

At 0248 hours, eight Apache helicopters pushed into enemy territory, flying fifty feet above the ground at 120 mph. Lieutenant Colonel Johnson, the Black Team commander, assigned the lead aircraft the primary mission of navigation. Each relied on a TADS/PNVS suite, enabling them to fly and fight at night in bad weather. For operational security, the team flew at high speed and low altitude with navigation lights blacked out and total radio silence, a dangerous combination. They were going in to strike a newly detected critical mobile target, a concentration of surface-to-surface missiles (SSMs) which had just deployed in the deep battle area.

Suddenly the sky, hills, and ground below were surreally lit by a blinding flash as the lead helicopter exploded. As night vision devices returned to normal, trailing crews detected incoming missiles.

Acoustics on the 21st Century Battlefield

By MARVIN G. METCALF

Several of the Apaches fired their 2.75 inch (70mm) Hydra rockets in the direction of the attackers. The team then went to ground, hovering low in any covered or concealed position that was available. The rearmost Apache had time to detect and hit an enemy Mi–28 Hokum helicopter with a well-placed Longbow Advanced Hellfire missile.

Attackers and defenders hovered in effective hide positions. Luckily for the Black Team, the attack seemed to be a chance engagement rather than a prepared ambush. The ensuing battle, during which both sides maneuvered for position, was like a firefight between two infantry patrols with troops dodging from rock to tree as their teammates tried to pick off any enemy soldiers who happened to expose themselves to fire.

Johnson knew that time was on the side of the enemy, whose ground forces, surface-to-air weapons, and perhaps attack helicopter reinforcements would soon arrive. Disengaging would be difficult. So he gave the order to use his unit's new weapon system: "Fire acoustic missiles!"

U.S. Army

Each helicopter fired two missiles which rose to an altitude at which discriminating sensors could quickly detect, locate, and identify enemy Hokum helicopters. The Hokums hovered out of sight behind tree stands, hills, and buildings, but to no avail. Within seconds the missiles pitched over and homed in on their targets. They fell straight down through the rotor blades destroying all six of the remaining Hokums.

Colonel Johnson played it safe. After counting the six explosions, he was fairly certain that the acoustic missiles had destroyed all or nearly all the engaging enemy helicopters. He then cautiously began to maneuver his team out of the area. Within moments, the Black Team was again en route to the target area. This mission was critical: the enemy SSMs had to be destroyed.

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Are there really acoustic missiles that can detect, identify, and home in on enemy targets? Even flying targets like Hokums? This may be technology of the future, but it is just around the corner. A prototype acoustic homing sensor system is being tested as the brilliant anti-tank (BAT) submunition for the Army tactical missile system (ATACMS) or for the tri-service stand-off attack missiles (TSSAM).

To stay ahead of the power curve, commanders should anticipate high-tech weapons such as acoustic missiles. Many technologies will emerge, proffering more opportunities for high-tech battlefield applications. The operational commander of the 21st century must understand, integrate, and apply innovative capabilities to find, fix, fight, and finish enemy forces.

Targets and Sensors

Acoustics exemplify emerging technologies with great potential for the high-tech battlefield. The acoustic-based seekers are ideal as wide area target acquisition sensors. Coupled with terminal guidance sensors, they can find and kill targets. That such precision strike weaponry—acoustic or otherwise—is the wave of the future even impressed the public during the Persian Gulf War.

More accurate sensors require smaller warheads which offer economical trade-offs. These warheads reduce logistical requirements as well as inflict less collateral damage and fewer civilian casualties. Such technological advances will yield several significant gains for future warfighting. The superiority of acoustic sensors for wide area target acquisition is derived from the technology itself. Various electromagnetic (radio/radar) or electro-optic (EO) sensors in general use today are able to receive only very narrow bandwidths. For instance, EO sensors can usefully picture only small, specific areas. Though scanning techniques can be used to broaden the field, a lot of time is necessarily lost trying to find the specific bandwidths or locations of likely targets. It is somewhat like scanning a large crowd for a particular individual through a straw.

Unlike existing sensors, an acoustic sensor is wide open, searching across all frequencies and angles. Also, it is very low in background noise. Its wide-open, simultaneous acquisition of all incoming signals means it is a much more efficient sensor, especially when complemented by a "soda-straw" sensor that can be pointed at the target for added data collection or terminal guidance.

The potential of acoustic technology was recently dramatized by applying it to anti-armor munitions in the form of BAT munitions. However, this development is merely an extension of the traditional military ear for listening to sounds on and around the battlefield.

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Sound Across the Ages

Commanders throughout history have used sound to pierce the fog of war—or maintain it to their advantage, as in muffling cannon wheels. This century has seen greater scientific interest in sound. Flash and sound ranging equipment was perfected during World War I to direction find (DF) enemy artillery. Sophisticated electronic sensors such as the Italian passive acoustic location system (PALS), Swedish sound ranging system-6 (SOARS-6), and Russian standard SCHZ-6 acoustic artillery ranging system are being employed to triangulate and locate enemy batteries.

Early in World War II, air defenders on both sides of the English Channel used simple airplane noise detectors, like giant stethoscopes aimed at the sky, to locate, track, and even identify aerial targets and the direction of aerial movements. Although surprisingly effective, these devices were soon overtaken by the new technology of radar.

Medieval armies dug tunnels to penetrate fortifications. Sophisticated tunnel detectors still are used along the demilitarized zone in Korea. Soldiers have always sought an effective means of detecting underground sounds, the seismic subset of acoustic technology.

In Vietnam unattended ground sensors (UGS) included the air-deliverable seismic intrusion detection system (ADSIDS) and the remotely monitored battlefield sensor system (REMBASS), which included seismic, acoustic, magnetic, and infrared sensors to detect the movement of people and vehicles. These were tactically placed to track troops along the DMZ, Ho Chi Minh Trail, and elsewhere. Current wide area mine systems (WAMS) and artillery-delivered ground sensors also use seismic sound to detect target movements.

Even so, acoustics technologies emerging on the 21st century battlefield offer the prospects of a major leap forward from contemporary UGS and WAMS-type systems, just as the minié ball rifle of the Civil War surpassed the Brown Bess smooth-bore musket of the Revolutionary War. The new BAT submunition is just the tip of the acoustics iceberg. BAT represents only an initial step in the development of future acoustics sensor capabilities.

Seeking Acoustic Signatures

The distinctive aspect of the revolution in 21st century battlefield acoustics is not found in acoustics technology itself, but in advances in other unrelated, parallel technologies. Specifically, it comes from synergistic applications of developments in miniaturized, high-tech data processing capabilities which have appeared recently.

Earlier uses of acoustics amplified our natural sense of hearing by mechanical means. Later technology added sophisticated electronic amplifications of sound waves. However, this process was limited to simply making ambient sound audible to human ears so that people could respond. In the

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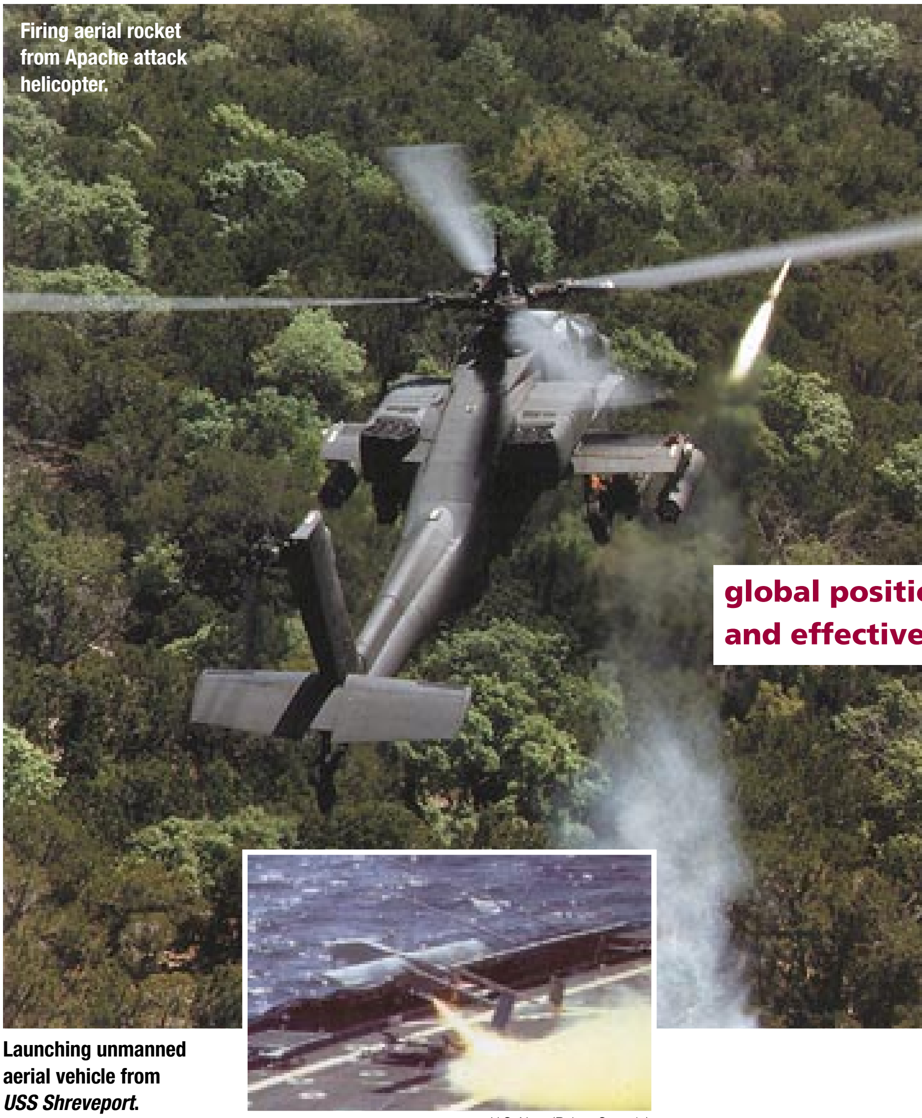

Firing aerial rocket from Apache attack helicopter.

McDonnell Douglas

Launching unmanned aerial vehicle from *USS Shreveport*.

U.S. Navy (Robert Scoggin)

case of listening posts, audio detectors, remote seismic detectors, and other devices, sound was detected and monitored by humans or electronically reported to have occurred, such as using remote UGS.

Recently developed artillery ranging systems and acoustic sensor munitions have only been incremental improvements. Sounds detected by sensitive directional microphones that are used in the PALS system are computer-processed to provide data readouts for its operators. When seismic sensors detect approaching targets, WAMS mines automatically dispense high-flying, sensor-fused submunitions to find and destroy them. Yet these systems only detect noise and respond to it.

The distinction between current systems and BAT technology is simple. Assisted by high-tech, miniaturized, high-speed, high-capacity, on-board data processing, the BAT acoustics system not only hears a target but analyzes sound waves. Using differentiating characteristics, BAT filters all sounds which its wide-open sensors acquire to focus on and attack selected targets. Moreover, as difficult as such target discrimination can be from a static ground platform, BAT sensors detect it from an air vehicle moving at high speed.

Operating acoustic sensors from a flying platform has challenged designers and engineers. If ground noise was undistinguished from platform noise, the system simply could not differentiate the sounds of various targets. Acoustics pioneers thus devised methods to distinguish platform or engine noise, in part by borrowing techniques and fancy signal data processing from radar. Using on-board microcomputers to manipulate noise parameters such as amplitude and phase, they could filter out self-noise from even high-speed, flying platforms like BAT. Once designers produced flying acoustic sensors that worked, various battlefield applications became readily apparent.

global positioning is bolstering the accuracy and effectiveness of high-tech weaponry

Taking practical advantage of acoustic weapons combined with the reconnaissance vehicles required the simultaneous, parallel development of microcomputer processing, including advanced miniaturization, that provided on-board computers with significant processing power and memory. The on-board computer facilitates the signal processing and acoustic signature matching. It also handles on-board mission planning and navigation systems for autonomous operations of potential unmanned aerial vehicles (UAVs) applications of acoustic sensor technology.

The increasingly ubiquitous global positioning system (GPS) is bolstering the accuracy and effectiveness of emerging, high-tech weaponry. Most missile and unmanned vehicle systems of the next century will be designed to function with GPS-based navigational systems and follow-on generations of this technology for convenience, accuracy, and effectiveness.

Ears to the Ground

The most significant aspect of synergistically developed acoustic weapons will be an ability to find and discriminate among targets using distinctive acoustic signatures. BAT submunitions launched from ATACMS or multiple-launch rocket system (MLRS) munitions employ relatively simple capabilities to detect and home in on engine noises from enemy tanks. More sophisticated applications, such as acoustic anti-helicopter missiles described earlier, use acoustic-based sensors to detect and select a given target for which a missile is programmed. Once a target is selected, the missile homes in and destroys it.

Missiles on reconnaissance, surveillance, and target acquisition (RSTA) missions will be able to detect and identify targets that it has been programmed to recognize, report their locations to J-STARS or ground station modules, and perhaps cue sensor platforms to commence an attack or initiate more detailed intelligence gathering. This technology will turn precision strikes into ultra-precision strikes. The added accuracy and target discrimination made possible by advanced sensor systems will transform surgical operations into *arthroscopic* surgical operations.

many targets cannot operate without generating a detectable signature

The first step in the process of target acquisition, identification, and designation is to screen out ambient sounds. Acoustic receivers are always wide open and thus hear everything. Filtering ambient background noises makes it possible for further specific noise filtering and wave analysis. The self-noise generated by a vehicle engine and air turbulence created by movement of a vehicle is filtered out and identified during reception.

Remaining sounds are isolated by factors such as frequency and amplitude with detectable acoustic signatures plotted like visual graphics in a voice-based lie detector. The acoustic signature of a target type such as the T-80 tank, like human voiceprints, is distinctive—at least sufficiently for targeting purposes. For example, consider the success that the Navy had in the 1970s and 1980s using underwater microphones (or hydrophones) to collect the unique acoustic signature of submarines.

Next, a system must identify discriminating characteristics that distinguish the sound being monitored: frequency, harmonic frequency relationships, amplitude, and changes in frequency and amplitude. Such characteristics can identify a class of targets, a target type, or an individual target. Comparisons of incoming sound signals are made literally hundreds of times per second against unique characteristics of recorded targets. If a match does not occur, the unmatched target sensing is dropped, and the computer continues to seek matches for other signals. Given such a massive computational requirement, the importance of powerful, on-board computers is evident.

Another advantage of seeking acoustic signatures to locate and identify potential targets is that it adds yet another dimension to a threat. Like our own forces, an enemy can hide from visual detection behind camouflage nets or more substantial cover. Similarly enemy forces can hide from infrared detectors and remotely locate their antennas as well as use emission control to protect radio frequency emitters.

Sending Out Pings

Countermeasures will be attempted, but an enemy must hide its acoustic signature. Many targets cannot operate without generating a detectable signature. For example, tanks cannot move without running acoustically distinctive engines or making acoustically distinctive track noises. On the future battlefield acoustic factors may become the proverbial straw that breaks the camel's back when an enemy attempts to conceal its assets.

Target files, developed and preprogrammed in the mission computer of an acoustic missile, can be updated as required. The missile can be programmed to respond only to specific target sets. On the other hand, RSTA missions may require that an entire target list be left wide open in order to identify the full range of targets which a reconnaissance mission might encounter and report.

One constraint on acoustic-sensor weapon systems envisioned for the mid-term is that the sensors are passive. A column of tanks with its engines off may avoid detection by an overflying acoustic missile. Yet the next generation of R&D may address this handicap through a refinement of acoustic technology: active acoustic sensors. Operating like an aerial sonar, sending out pings and detecting returns from desirable targets, they could yield a greater magnitude of collection and accuracy capability to acoustic systems. An advanced WAMS could use acoustic sensors to locate, identify, and select targets. Another potential acoustic system might employ a network of active acoustic sensors seeded across an enemy rear area to report on movements and activities.

Future commanders must anticipate uses of more advanced technologies, especially missile delivery systems linked to acoustic technology which identifies, selects, and finds critical targets. Conversely, operational commanders must be able to defend against comparable capabilities.

Acoustic science is just one area of emerging high technology with applications for the next century. Analysis of its potential reveals rapidly developing trends and battlefield applications that such discoveries may offer or even impose. No nation can afford to ignore the accelerating march of such militarily applicable technology. Europe, Japan, and certain Third World nations have the skilled scientists and technicians who may discover the next war-winning technology. In the wake of the Gulf War, the Russians have acknowledged the importance of winning the information war and established information as a "fourth realm" of warfighting doctrine (after land, sea, and air).

The most successful commanders on the battlefield of the future will understand and apply integrated systems of advanced technology. Our most critical training mission is to ensure that our leaders understand and anticipate the potential and complexity of near future warfare. JFQ